

Clean copy of the allowed claims

4. A computer implemented method of simulating a circuit, the method comprising:
- defining a set of differential-algebraic equations of the circuit;
 - defining a simulation time interval corresponding to the differential-algebraic equations;
 - dividing the simulation time interval into time intervals, wherein the time intervals have corresponding polynomials for each time interval, wherein each polynomial is a portion of an approximation to a desired solution of the differential-algebraic equations; and
 - applying a collocation method to discretize the differential-algebraic equations; wherein:
 - the simulation time interval has M collocation points, and wherein M represents a highest degree of interpolating polynomials;
 - determining a smoothness for each interval, increasing an order of a solution for an interval if it is smooth, and splitting the interval into at least two sub-intervals if the interval is not smooth;
 - solving the differential-algebraic equations in each of the intervals wherein approximation to the desired solution of the differential-algebraic equations is
$$I_M u(t) = \sum_{k=0}^M u_k \tilde{T}_k(t),$$
wherein
 - I_M represents an M-point interpolation operator,
 - $u(t)$ represents a solution,

$u_k \sim$ represents Fourier coefficients, and

$T_k(t)$ represents the interpolating polynomial.

3. The method of Claim 4, wherein located at each collocation point t_j is a value of $u(t_j)$ respectively, to be interpolated with polynomials.

5. A computer implemented method of simulating a circuit, the method comprising:

defining a set of differential-algebraic equations of the circuit;

defining a simulation time interval corresponding to the differential algebraic equations;

dividing the simulation time interval into time intervals, wherein the time intervals have corresponding polynomials for each time interval, wherein each polynomial is a portion of an approximation to a desired solution of the differential-algebraic equations; and

applying a collocation method to discretize the differential-algebraic equations;

wherein:

the simulation time interval has M collocation points, and M represents highest a degree of interpolating polynomials;

determining a smoothness for each interval, increasing an order of a solution for an interval if it is smooth, and splitting the interval into at least two sub-intervals if the interval is not smooth;

solving the differential-algebraic equations in each of the intervals wherein approximation to the desired solution of the differential-algebraic equations is

$$I_M u(t) = \sum_{k=0}^M u_k \tilde{T}_k(t),$$

wherein

I_M represents an M-point interpolation operator,

$u(t)$ represents a solution,

$u_k \tilde{}$ represents Fourier coefficients,

$T_k(t)$ represents the interpolating polynomial; and

a derivative of the approximation is $(I_M u)'(t) = \sum_{k=0}^M u_k \tilde{}' T_k(t)$,

wherein $u_k \tilde{}'$ represents the Fourier coefficients' derivative.

6. The method of claim 5, wherein each coefficient $u_k \tilde{}'$ is computed from $u_k \tilde{}$.

7. The method of claim 5, wherein the circuit is a radio frequency (RF) circuit.

8. The method of claim 4, wherein the step of applying the collocation method comprises applying Chebyshev collocation to discretize the set of differential-algebraic equation.

19. A computer implemented method of solving a set of differential-algebraic equations arising in a circuit simulation, the method comprising:

applying a collocation method to each differential-algebraic equation to discretize the set of differential-algebraic equations;

forming a solution to the set of differential-algebraic equations based on the discretized differential-algebraic equations; and

determining an order of accuracy desired in intervals of the differential algebraic equations to be solved in the simulation;

wherein:

the set of differential-algebraic equations comprises a set of boundary-value differential-algebraic equations, and wherein the boundary-value differential-algebraic equations are discretized in the intervals, and wherein neighboring intervals share a boundary; and

the solution in a particular interval is smooth, and wherein the step of determining the order of accuracy desired in each interval comprises determining whether to increase the order of accuracy of the particular interval.

10. The method of Claim 19, wherein the set of differential-algebraic equations comprises at least one of: a set of initial-value differential-algebraic equations and a set of boundary-value differential-algebraic equations.

20. A computer implemented method of solving a set of differential-algebraic equations arising in a circuit simulation, the method comprising:

applying a collocation method to each differential-algebraic equation to discretize the set of differential-algebraic equations;

forming a solution to the set of differential-algebraic equations based on the discretized differential-algebraic equations; and

determining an order of accuracy desired in intervals of the differential algebraic equations to be solved in the simulation;

wherein:

the set of differential-algebraic equations comprises a set of boundaryvalue differential-algebraic equations, and wherein the boundary-value differential-algebraic equations are discretized in the intervals, and wherein neighboring intervals share a boundary; and

the solution in a particular interval is not smooth, and wherein the step of determining the order of accuracy desired in each interval comprises splitting the particular interval into at least two subintervals.

11. The method of Claim 20, wherein the circuit simulation is a radio frequency (RF) circuit simulation.

12. The method of Claim 20, wherein the step of applying the collocation method comprises applying Chebyshev collocation to each differential-algebraic equation to discretize the set of differential-algebraic equations.

14. The method of Claim 19, further comprising enforcing continuity of the solution at the boundary of neighboring intervals.

15. The method of Claim 20, wherein the set of differential-algebraic equations comprises a set of boundary-value differential-algebraic equations discretized into intervals, and wherein the boundary-value differential-algebraic equation intervals include a first and a last interval.

16. The method of Claim 15, further comprising enforcing a boundary condition at a boundary of the first and the last interval.

17. The method of Claim 20, further comprising:
solving the set of differential-algebraic equations using a Newton-Raphson iterative method; and
in each Newton-Raphson step of the Newton-Raphson iterative method, solving a linear Jacobian system using a linear iterative method.

21. The method of Claim 17, further comprising separately approximating for each interval a local preconditioner.

22. The method of Claim 21, wherein the local preconditioner comprises at least one of: a capacitance matrix; and a conductance matrix.

34. A computer-readable medium carrying one or more sequences of one or more instructions for solving a set of differential-algebraic equations arising in a circuit simulation, the one or more sequences of one or more instructions including instructions

which, when executed by one or more processors, cause the one or more processors to perform the steps of:

applying a collocation method to each differential-algebraic equation to discretize the set of differential-algebraic equations;

forming a solution to the set of differential-algebraic equations based on the discretized differential-algebraic equations; and

determining an order of accuracy desired in intervals of the differential algebraic equations to be solved in the simulation;

wherein:

the set of differential-algebraic equations comprises a set of boundary value differential-algebraic equations, and wherein the boundary-value differential-algebraic equations are discretized in the intervals, and wherein neighboring intervals share a boundary; and

the solution in a particular interval is not smooth, and wherein the step of determining the order of accuracy desired in each interval further causes the processors to carry out the step of splitting the particular interval into at least two subintervals.

24. The computer-readable medium of Claim 34, wherein the set of differential-algebraic equations comprises at least one of: a set of initial-value differential-algebraic equations and a set of boundary-value differential-algebraic equations.

25. The computer-readable medium of Claim 34, wherein the circuit simulation is a radio frequency (RF) circuit simulation.

26. The computer-readable medium of Claim 34, wherein the step of applying a collocation method further causes the processors to carry out the step applying Chebyshev collocation to each differential-algebraic equation to discretize the set of differential-algebraic equations.

28. The computer-readable medium of Claim 34, wherein the instructions further cause the processors to carry out the step of enforcing continuity of the solution at the boundary of neighboring intervals.

29. The computer-readable medium of Claim 34, wherein the set of differential-algebraic equations comprises a set of boundary-value differential-algebraic equations discretized into intervals, and wherein the boundary-value differential-algebraic equation intervals include a first and a last interval.

30. The computer-readable medium of Claim 29, wherein the instructions further cause the processors to carry out the step of enforcing a boundary condition at a boundary of the first and the last interval.

31. The computer-readable medium of Claim 34, wherein the instructions further cause the processors to carry out the steps of:

solving the set of differential-algebraic equations using a Newton-Raphson iterative method; and

in each Newton-Raphson step of the Newton-Raphson iterative method, solving a linear Jacobian system using a linear iterative method.

33. A computer-readable medium carrying one or more sequences of one or more instructions for solving a set of differential-algebraic equations arising in a circuit simulation, the one or more sequences of one or more instructions including instructions which, when executed by one or more processors, cause the one or more processors to perform the steps of:

applying a collocation method to each differential-algebraic equation to discretize the set of differential-algebraic equations;

forming a solution to the set of differential-algebraic equations based on the discretized differential-algebraic equations; and

determining an order of accuracy desired in intervals of the differential algebraic equations to be solved in the simulation;

wherein:

the set of differential-algebraic equations comprises a set of boundary value differential-algebraic equations, and wherein the boundary-value differential-algebraic equations are discretized in the intervals, and wherein neighboring intervals share a boundary; and

the solution in a particular interval is smooth, and wherein the step of determining the order of accuracy desired in each interval further causes the processor to carry out the step of determining whether to increase the order of accuracy of the particular interval.

35. The computer-readable medium of Claim 31, wherein the instructions further cause the processors to carry out the step of separately approximating for each interval a local preconditioner.

36. The computer-readable medium of Claim 35, wherein the local preconditioner comprises at least one of: a capacitance matrix; and a conductance matrix.

37. A computer implemented method of simulating an RF circuit, comprising the steps of:

determining a plurality of differential-algebraic equations describing operation of the RF circuit;

determining a set of Chebyshev Gauss-Lobatto collocation points for the plurality of differential-algebraic equations, producing a set of intervals;

discretizing each of the differential-algebraic equations based on the Chebyshev Gauss-Lobatto collocation point intervals;

determining a smoothness for each interval, increasing an order of a solution for an interval if it is smooth, and splitting the interval into at least two sub-intervals if the interval is not smooth;

solving the differential-algebraic equations in each of the intervals; and

simulating the RF circuit based on the solved intervals.

38. A computer implemented method of simulating an RF circuit, comprising the steps of:

determining a plurality of differential-algebraic equations describing operation of the RF circuit;

determining a set of Chebyshev Gauss-Lobatto collocation points for the plurality of differential-algebraic equations, producing a set of intervals;

discretizing each of the differential-algebraic equations based on the Chebyshev Gauss-Lobatto collocation point intervals;

solving the differential-algebraic equations in each of the intervals; and

simulating the RF circuit based on the solved intervals;

wherein the step of solving comprises applying a set of at least one high order solution to at least one of the intervals and applying at least one solution from a set of low order solutions to a plurality of the intervals.

39. The method according to Claim 38, wherein the step of solving comprises applying a set of solutions comprising more low order solutions than high order solutions.

40. The method according to Claim 38, further comprising the steps of:
dividing the intervals into smooth and non-smooth intervals, applying higher order solutions to the smooth intervals, and applying lower order solutions to the non-smooth intervals.

41. A computer implemented method of simulating an RF circuit, comprising the steps of:

determining a plurality of differential-algebraic equations describing operation of the RF circuit;

determining a set of Chebyshev Gauss-Lobatto collocation points for the plurality of differential-algebraic equations, producing a set of intervals;

discretizing each of the differential-algebraic equations based on the Chebyshev Gauss-Lobatto collocation point intervals;

solving the differential-algebraic equations in each of the intervals; and

simulating the RF circuit based on the solved intervals;

wherein the Chebyshev Gauss-Lobatto collocation points produce a small number of intervals in areas in which the differential-algebraic equations exhibit high convergence, and a large number of intervals in areas where the differential-algebraic equations exhibit low convergence.

42. The method according to Claim 41, wherein the step of solving comprises dividing the intervals into smooth and non-smooth intervals, applying higher order solutions to the smooth intervals, and applying lower order solutions to the non-smooth intervals.

43. The method according to Claim 37, further comprising the steps of:
enforcing continuity of the solution at each interval boundary; and
enforcing a periodic boundary condition at each first and last interval boundaries.

44. A computer implemented method of simulating a circuit, comprising the steps of:
determining a plurality of differential-algebraic equations describing operation of the circuit;

determining a set of collocation points for the plurality of differential-algebraic equations, producing a set of intervals comprising at least one high convergence interval and a plurality of low convergence intervals;

applying a higher order solution in the at least one high convergence interval;
applying a lower order solution in the low convergence intervals; and
simulating the circuit response using the higher and lower order solutions.

45. The method according to Claim 44, wherein the collocation points comprise Chebyshev Gauss-Lobatto collocation points.

46. The method according to Claim 44, further comprising the steps of:
enforcing continuity of the solutions at each interval boundary; and enforcing a periodic boundary condition at each first and last interval boundaries.

47. The method according to Claim 44, further comprising the steps of:
enforcing continuity of the solutions at each interval boundary; and
enforcing a periodic boundary condition at at least one of the first and last interval boundaries.

48. The method according to Claim 44, wherein more low order solutions are applied to the differential-algebraic equations than high order solutions.